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OF

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Proceedings of the October Quarterly Meeting

Subject: The Purification of Water by Freezing

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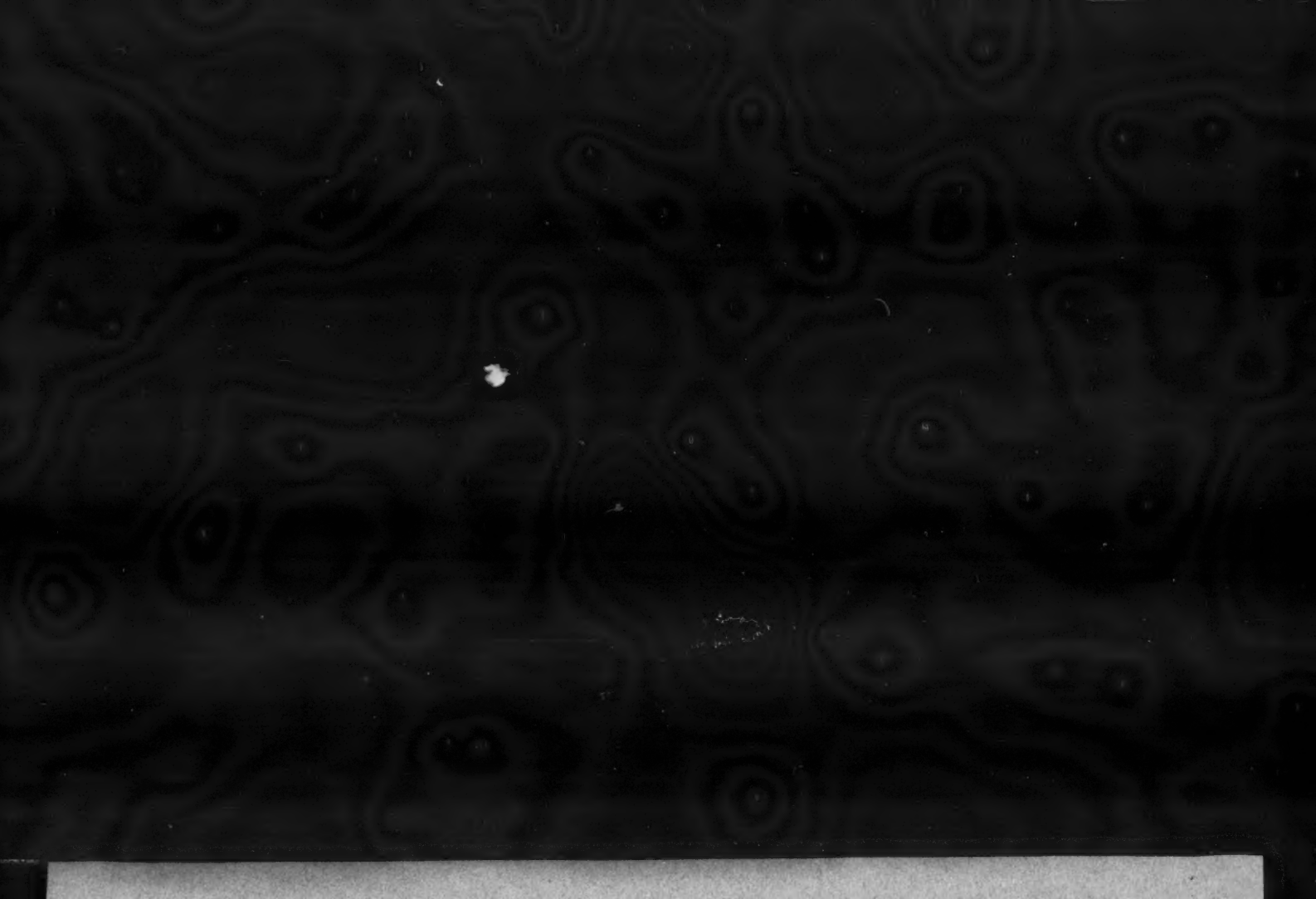

JOURNAL OF THE MASSACHUSETTS ASSOCIATION OF BOARDS OF HEALTH

October Meeting, 1901

SUBJECT: The Purification of Water by Freezing

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OCTOBER MEETING

OF THE

Massachusetts Association of Boards of Health.

The October quarterly meeting of the Massachusetts Association of Boards of Health was held in Boston at the Parker House on the afternoon of Wednesday, October 23, Dr. Henry P. Walcott, the President, in the chair.

The PRESIDENT. — The Executive Committee recommends to the Association for membership in the Association Dr. Lyman F. Bigelow of the Norwood Board of Health. Is it your pleasure that he be elected a member of this Association?

Dr. Bigelow was elected to membership.

The PRESIDENT. — The Secretary will read the records of the last meeting of this Association.

Mr. James C. Coffey, the Secretary, read the records of the July meeting.

The PRESIDENT. — Is there any change to be made in the record that has been read to you? If not, it will stand as the record of the

last meeting of this Association. Mr. Clark will now read his paper upon "A Study of the Purification of Water by Freezing."

THE PURIFICATION OF WATER BY FREEZING.

The question of the purity of an ice supply harvested from a pond or river the water in which is more or less open to suspicion, owing to the entrance of drainage, is one that has given many persons much uneasiness of mind and many misgivings as to the desirability of using such ice. Thirteen years ago the legislature of Massachusetts directed the State Board of Health to make, in the words of the resolve, "a special investigation with reference to the pollution of ponds, lakes, streams, or other bodies of water used as ice supplies in this State, especially with reference to the effect of such pollution upon the healthfulness of such ice for domestic use." In accordance with this direction the board made an elaborate investigation, the results of which were published in the annual report for the year 1889. Circulars were sent out to every city and town in the State, to local boards of health, physicians, etc., and replies asked to four questions. One of these questions was, "Have any cases of illness come to your knowledge from the use of ice cut from such sources (that is, polluted sources)?" and it is noticeable that, in the one hundred eighty-nine replies received, the answer to this question was generally "No." A few cases, however, in the language of the board, "were noted where the ice supply was suspected to be the cause of illness; but none appeared to be so definitely connected with this cause as to give promise of additional knowledge, if investigated further."

The conclusions of that investigation of the board were, briefly stated, as follows: "Taking an average of all the water and ice used for ice supplies which we have examined, we find that the organic impurities of the snow ice as shown by the sum of the ammonias," in the words of the writer of the report, "amount to 69 per cent. of those of the waters, that the organic impurities of all the ice except the snow ice amount to 12 per cent. of those of the waters, and those of what we call clear ice amount to 6 per cent. of the impu-

rities of the waters. There were 81 per cent. as many bacteria in the snow ice as in the waters, 10 per cent. as many in all other ice, and 2 per cent. as many in the clear ice as in the waters. The results obtained lead to the conclusions that, while clear ice from polluted sources may contain so small a percentage of the impurities of the source that it may not be regarded as injurious to health, the snow ice and any ice, however clear, that may have been formed by flooding, is likely to contain so large a percentage of the impurities of the source, and with these impurities some of the disease germs that may be in the source, that the board feels bound to warn the public against using ice for domestic purposes which is obtained from a source polluted by sewage beyond that which would be allowable in a drinking water, and placing in contact with food that portion of the ice which is clear." In that investigation all the analyses made were of samples of water and of ice collected from the various places in the State named in the report.

This work followed quickly after that of Dr. T. Mitchell Prudden, published in the *Medical Record*, vol. 31 ; and the conclusions reached in regard to the variation in the quality of ice from different portions of the same cake were practically identical. But Dr. Prudden's investigations were entirely with the ice of the Hudson River, while the board's investigations, with nearly three hundred analyses of samples of ice and water, covered a large number of different supplies of both water and ice.

In the thirteen years that have elapsed since that report was made, methods of bacterial analysis have improved somewhat; and during the past two winters we have been making a second investigation in regard to the purification of water by freezing, in order to gain additional knowledge upon some points that are evidently of importance, if questions in regard to ice formed under widely differing conditions are to be always intelligently answered. In this investigation more attention has been paid to the examination of ice formed in tanks in water polluted to degrees which we more or less controlled, although quite a number of samples of ice, together with samples of water, have been taken from rivers and ponds known to be polluted and from which ice supplies are sold for domestic use.

It is evident that the chemical and bacterial examination of a cake

of ice shipped to a laboratory, while satisfactory to the analyst as showing with considerable definiteness the character of this particular cake, has seemed to mean but little at times, when considering the ice supply as a whole from which the cake was taken and the method in which it was harvested. A report from the analyst, therefore, showing this cake to be of an entirely satisfactory quality, and, therefore, the ice safe to use, is often exactly opposed to the opinion of the collector of the cake, who has examined the source of the ice supply in question, and detected numerous chances of pollution, even though this collector may know perfectly well that bacterial and chemical purification of water occurs during freezing. Just how great this purification is, under the varying conditions that must obtain in different ponds and rivers containing water of a varying quality, has not, of course, been definitely known to us, even after the thorough investigation referred to. It was hoped, therefore, that by this second investigation we should determine this point as nearly as possible. Besides this, we have not known as well as could be desired the difference in purification that occurs with ice formed in quiet water compared with ice formed in water moving with different degrees of rapidity; and in regard to this we also hoped to gain information, as river ice is, of course, largely used in some places. The effect of the depth of the water in which the ice is formed, in regard to the purification occurring, was also a point upon which more definite information was desired.

During the winter of 1900–1901 we made some investigations in regard to the retention of bacteria in ice during the freezing of water, and the length of life of these bacteria under these conditions; and during last winter the investigations were continued. In the first work the experiments were so conducted that all the water placed in a pail or small tank was frozen, this, of course, not being the manner in which ice is formed upon most of our natural ice supplies, although much of the ice from artificial ice plants is formed in this way, this ice, however, being generally formed from what is supposed to be very pure natural water and often distilled water. It can be stated, however, that we have found many instances in the State where villages or sections of towns are supplied with ice harvested from ponds of so shallow a depth of water that practically all the

water is frozen, and in these instances the ice resembles more or less closely the ice formed in these first experiments.

In these experiments we used a polluted river water and also sewage, and found, as was expected, that, when freezing all of the water in a receptacle, a very large proportion of the bacteria in the water frozen was killed in the process of freezing, but still a very large number was left in the ice and lived for a number of weeks. It was found, also, in freezing water in this way that the outer portion of the water, not only that on the surface, but also that around the outside of the pail, was the first to be frozen, and that this caused the bacteria to be so driven toward the centre of the water in the pail that the ice that was formed last — that is, in the centre — would contain the greater number of bacteria. For instance, in one experiment, where the water used contained 2,600 bacteria per cubic centimetre and 115 B. coli, the outer ice of the cake contained only from 100 to 600 bacteria per cubic centimetre with no coli present, while the ice formed in the centre of the cake contained, when examined even at a considerably later date, from 5,000 to 20,000 bacteria per cubic centimetre. I have mentioned the number of B. coli here; and, in all of our work, not only was the number of all bacteria in the water and ice determined, but also as nearly as possible the number of the colon bacillus present, this being the characteristic organism of sewage.

In another instance, when carrying on an experiment of this nature, where the liquid frozen in the tank was sewage, this sewage before freezing contained 1,500,000 bacteria per cubic centimetre; the ice first formed — that is, the outside of the cake — contained 74,000 bacteria per cubic centimetre; the ice toward the centre of the cake, 121,000 bacteria per cubic centimetre; and the unfrozen sewage in the centre of the cake, 640,000 bacteria per cubic centimetre. The same relation held true with the coli present in the water and the ice; that is, 320,000 coli per cubic centimetre in the sewage before freezing, 7,000 in the outside ice of the cake, 9,000 in the inside ice, and 52,000 in the unfrozen sewage in the centre of the cake. Many other experiments of this character were made, all showing what these two experiments that I have described illustrated; that is, that in freezing a solid block of ice a very great number of bacteria were retained within this ice, and that these bacteria would

live for a number of weeks. In these experiments upon freezing the entire volume of water, the best bacterial purification shown by freezing was 85 per cent.; that is, 85 per cent. of the bacteria in the sewage or water were not found in the best portions of the ice formed, but generally the bacterial purification was very much less than this.

The further investigations made were in regard to the points previously mentioned: the purification both bacterially and chemically of ice formed on different depths of water, water polluted to different degrees, and water polluted to equal degrees, but moving with different degrees of rapidity.

The results in regard to the different degrees of purity obtained when waters were frozen in receptacles containing different depths of the liquid averaged as follows: with one foot in depth and with the ice formed occupying more than one-third of this depth, we obtained, when freezing, a water containing 7,100 bacteria per cubic centimetre, an ice containing 560 bacteria per cubic centimetre, or a bacterial purification of 92 per cent. This water before freezing contained 17 B. coli per cubic centimetre; but the ice formed was free from this organism, as far as our examinations could determine. Freezing a more polluted water, or perhaps I should call it sewage, in a tank of this depth, this sewage containing 500,000 bacteria per cubic centimetre, we obtained an ice containing 3,000 bacteria per cubic centimetre, or a bacterial purification of 99 per cent.,— a large percentage removal, but still a very large number of bacteria caught in the ice.

During the winter of 1900–1901 the investigation was continued, and very many experiments were made, in which volumes of water of varying degrees of purity were exposed in tanks 6 feet deep and 28 inches in diameter; and the ice formed upon these tanks was carefully examined. In all of this experimental work it was found that from 95 to 99 per cent. of the total numbers of bacteria in the waters experimented with were eliminated from the water during freezing, and that, whenever a water not more polluted than the Merrimack River water at Lawrence, into which, however, the unpurified sewage of a number of cities flows, was frozen in these tanks, every colony of the colon bacillus was killed or excluded from the ice formed, judging from our examinations. That is, the bacterial purification by freezing that occurred in these deeper tanks was much greater than occurred in the

shallower depth of water already described. When, however, we increased the pollution of the river water by adding 5 per cent. by volume of sewage, so that the number of B. coli present was made about five times as great, the ice formed contained this germ, together with a greatly increased number of other bacteria.

Besides these experiments in the tanks, a number of samples of ice for chemical and bacterial examination were taken as it formed upon running water, such as the polluted Merrimack River, and from still water, also polluted to a greater or less extent, samples of water being collected also wherever samples of ice were collected. Twice during the winter a series of samples of ice and water was collected from the river at different points above Lawrence and between Lawrence and Lowell, and examined both chemically and bacterially, these samples being collected at distances varying from three to eight and one-half miles below the outlets of the sewers of Lowell, Lowell being a city of 90,000 inhabitants, and emptying all of its sewage into the river. Examination of all these ice samples showed that, while the average number of bacteria in the river water, collected at the same locations from which our ice samples were taken, was 4,100 per cubic centimetre, the average number of bacteria in the ice was 9 per cubic centimetre, showing an elimination of 99.78 per cent. The average number of B. coli in the river water was 120 per cubic centimetre, and this germ was not found in any of the ice samples examined. That is to say, the number of bacteria found in this ice formed upon the river was less than the number in the ice formed from the same river water in our experimental tanks. While this was partly due to the greater depth of water in the river than in our tanks, still the river ice had been formed for a number of weeks before collection and examination, while the tank ice was examined generally within a few hours of forming. This second difference probably accounts very largely for whatever difference there was in number of bacteria found, as the river ice had been formed long enough for many bacteria, at first retained in it, to die. The chemical results of this examination of the river ice showed an elimination of organic impurities as follows: —

PERCENTAGE ELIMINATION.

1901.	Color.	Ammonia.			Chlorine.	Nitrogen as		Oxygen consumed.	Hardness.	Bacteria per cubic centimetre.	B. coli per cubic centimetre.
		Free.	Albuminoid.								
			Total.	In solution.		Nitrates.	Nitrites.				
Jan. 22	86.5	50.6	64.3	70.3	93.1	76.2	—	77.8	88.9	99.7 99.9	100.0
Feb. 20, top of cake .	72.2	40.3	44.1	—	85.7	80.0	—	44.2	91.7	99.2	100.0
Bottom of cake	86.1	86.1	74.6	—	100.0	92.0	—	86.0	100.0	99.9	100.0
Average . .	83.3	71.6	61.0	—	92.9	92.0	00.0	74.4	91.7	99.6	100.0

There is, moreover, at Lawrence a large water power and canals by which the river water is distributed to the various mills. In these canals the water is flowing at a much greater rapidity than the water in the river, and twenty-two samples of ice formed upon this swiftly moving river water were collected during the past winter and also examined for the presence of bacteria. It was noticed that the elimination of total numbers of bacteria in the ice formed under these conditions from the same river water was not nearly as great as in ice formed under the conditions in the river, where the water is moving much more slowly, and about 35 per cent. of the samples of ice collected from the canal that were examined contained colonies of the colon bacillus.

A large number of samples of ice and water from other ponds and rivers upon which the ice was formed under varying conditions of quietude or depth and degree of pollution were obtained, and in general the same results were found as in our experiments with water frozen under different conditions in our tanks and with the ice and water collected from the Merrimack River.

Summarizing, we can say that the power water has of purifying itself by its transformation into crystals of ice is well known, and is characteristic of crystallization. Studying the chemical analyses that we have made of samples of water and the ice formed from similar water, we find that not only is a considerable percentage of the bodies

in suspension in the water prevented from becoming embodied in the ice crystals formed, but also, what at first glance appears more remarkable, a larger percentage of the bodies in solution is thus prevented. Free ammonia, chlorides, and the mineral salts that cause hardness are all partially or entirely driven from the water frozen into the water remaining unfrozen. That a greater percentage of the mineral salts in solution is removed than of free ammonia is, perhaps, due to the greater density of the first bodies when in solution, and hence the greater ease with which they are driven out. Furthermore, it is evident that a substance such as ice, which in forming can free itself from the bodies in solution, must have a considerable power to prevent bacteria — that is, bodies of a tangible size and in suspension — from becoming entangled with it, particularly, as our experiments have shown, if there is a considerable depth of water under the ice forming, and if these bacteria do not have a tendency to rise. That bacteria do not have this tendency is, I think, a well-proved fact.

We found that not in one instance of the still freezing of ordinarily polluted water in our tanks, or still water in the ponds examined, were we able to find B. coli in the ice formed. When freezing Merrimack River water in tanks, the average number of bacteria of all kinds retained in the ice has been considerably less than 2 per cent. of the number in the water, and is a number averaging nearly as low as the average number we could expect in the effluent of a sand filter doing satisfactory work, and to which Merrimack River water was applied.

When freezing sewage in our tanks, or Merrimack River water made more polluted by the addition of 5 per cent. by volume of sewage, B. coli, together with a large number of other bacteria, has been retained in the ice formed; that is, here we have exceeded the limits of the bacterial and organic pollution which the ice, as it forms from the water and crystallizes, can overcome. When ice is formed in swiftly running water as polluted as that in the Merrimack River, where sedimentation is overcome to a certain extent, and there is a constant lateral or rolling movement of all the matter in suspension in the water, together with a tendency to prevent perfect crystallization because of this rolling movement, the danger of the retention of

bacteria in the ice is much greater, as shown by the canal ice results. This ice was but just formed, however, at the time of examination, while the ice from the river which was examined had been formed for perhaps several weeks, and hence time enough had elapsed for many bacteria to die.

In none of the fourteen samples, however, of ice collected by us that had formed upon the comparatively slowly moving river water between Lawrence and Lowell, did we find B. coli, and the bacterial efficiency of freezing, as shown by these samples, even including the bacteria in the top ice of each cake, was 99.78 per cent.; that is, the ice contained only 22 per cent. of the number of bacteria in the water from which it was formed.

It is evident, from all our experiments, that, if the ice formed is not to contain any considerable number of bacteria of any kind, it must be formed in such a place that all of the water is not frozen; and, the deeper and quieter the water under the layer of ice when forming, the less is the chance of bacteria being retained in the ice, this applying to ice formed upon both rivers and ponds. When, in order to thicken ice, the ice already formed on a pond or river is flooded and the entire volume of water over the ice is frozen, bacteria will undoubtedly be retained in this ice just the same as when the total volume of water in our pails was frozen, this point being distinctly brought out by the investigation and report of the board upon this subject in the year 1889. It is also evident that the point then made, that the top ice should be planed and removed before cutting and storing, is of value, not only on account of intentional flooding and of accidental flooding by a weight of snow on the ice, but also as there is a chance of many bacteria being frozen into the top ice at times of high wind when the first ice is forming, that is, the wind may stir the water to a considerable depth, overcoming sedimentation and the usual elimination of bacteria, and the water may wash over the ice as it forms.

On the whole, it is evident that the conditions surrounding water when it freezes are very important factors in determining the purity of the ice formed. If there is a considerable depth of water in portions of a somewhat polluted pond or river, and the ice is formed in these portions in comparatively quiet water, with but little matter in

suspension, this ice will probably be entirely satisfactory for domestic use, although a considerable drainage may enter the body of water upon which it forms. On the other hand, ice formed in shallow portions of such ponds or rivers, even during still weather, or in any portion, if there is a considerable movement of the water by currents or wind while it is forming, may be rendered by these conditions entirely unfit for domestic use. The instances, however, where the pollution of an ice supply are known to have caused disease are exceedingly rare. Lawrence is supplied very largely with ice cut from the Merrimack River; and yet, since the construction of the city filter, the typhoid death-rate of the city has been very low, owing to the excellent quality of the city water. In former years, moreover, the epidemics of typhoid fever occurred during the winter rather than in summer, when the consumption of ice is greatest.

THE PRESIDENT.—Mr. Clark's paper is before the Association for discussion; and the Association will be glad now to hear from Mr. Winslow, who, I understand, has something to say upon the subject.

Mr. WINSLOW.—I have been very much interested in Mr. Clark's valuable paper, because Professor Sedgwick and I did considerable work on this problem of the life of bacteria in ice, and especially the typhoid fever germ in 1898 and 1899. I am sorry that Professor Sedgwick is not here to discuss the paper himself, but he is unavoidably absent at the Yale Bi-centennial. He wished me to appear and say a word or two about our results, which have not yet been published in full, though they have been published in abstract. The full report has been delayed, but will be published, I hope, very soon.

It was generally assumed, I think, a few years ago that ice might be, and indeed was, a common source of infection in typhoid fever. Search through the literature, however, showed that the evidence from epidemiology was almost nothing, and that from experiment was very slight, indeed. We were unable to find a single instance of typhoid fever being definitely traced to ice supply. And, of all the numerous experiments carried out to determine the effect of cold on the typhoid germ, all but those of one observer were rendered practically insignificant because they were not quantitative. It was

clearly shown by many experimenters that, if typhoid fever germs in broth and agar cultures were frozen, sterilization did not ensue; but, as to the proportion of bacteria remaining alive in water after freezing, there was no evidence except in three experiments made by Dr. T. M. Prudden, of New York. (*Medical Record*, March 26, 1887.) One experiment showed a reduction of 80 per cent. in eight days, and another of nearly 95 per cent. in five days. In the third case the bacteria present in the water originally were innumerable, so that those results are not quantitative. On the strength of these results, from three experiments only with the typhoid germ, Dr. Prudden concluded the danger from infected ice was a very serious one. These three experiments, and one reported by Mr. Hiram F. Mills, in which typhoid germs died out in chilled water in 25 days (Rep. Mass. S. H. B. 1890, p. 542) furnished the only available data as to the quantitative reduction of typhoid fever bacteria effected by cold.

In our work, test-tubes of sterilized tap water were inoculated with pure cultures of the typhoid germ; and the attempt was made to secure significant results by the averaging of twenty tubes thus inoculated for each set of conditions. Four stock cultures were used; and it was found that the resistance of the four stocks, or "physiological races," as they may be considered, varied materially and rather constantly. The general results of these experiments for various periods of time are shown on the chart. This chart shows the results, the percentage reduction; that is, the percentage killed by freezing in the times indicated in the column on the left, for these four races, or four stock cultures. It begins with fifteen minutes, and each figure represents the averaging of twenty tubes. It will be noted that after two weeks an average of over 99 per cent. of the germs had perished in each case. During the first half-hour of the freezing a heavy but variable reduction took place. Sometimes 60 per cent. would be killed in one tube, and only 30 per cent. in the tube next it, for some reasons that we were unable to determine, possibly on account of the amount of culture medium or the physical conditions of freezing. At any rate, the conditions were very variable during the first half-hour. From this time on to about two weeks the reduction increased with the time,— the longer the tubes were frozen, the greater was the percentage reduction,— and

that increase was rapid during the first twenty-four hours, and then slower after that time. As I say, in two weeks in each case over 99 per cent. of the germs were killed. The two or three germs per thousand which survived the first two weeks appeared, however, to be specially resistant, and a considerable number of the tubes were not rendered sterile, even after twelve weeks; that is, a very few, two or three out of a thousand, remained alive. This, of course, explains the result of the previous observers, who froze up culture tubes containing millions and millions of germs, and found they were not sterilized. Alternate freezing and thawing appeared in our work, as in Dr. Prudden's, to be somewhat more effectual than continuous freezing, although even this process rarely brought about entire sterilization. The destruction of the germs in cool but unfrozen water followed very much the same laws as in the ice, and the percentage reduction of the germs was only slightly less in the water cooled down just above freezing. In water cooled almost to freezing the reduction was only a little less than it was in the ice. So that it appears that the mechanical effect of crystallization does not play any important part, as it was supposed it did. The reduction in individual tubes varied, however, much more widely in the water than in the ice, though the general percentage was nearly as great. There were a few individual tubes which did not show a marked reduction, whereas in the ice after twenty-four hours the results were quite constant. A few experiments on the behavior of typhoid bacilli when mixed with sterilized earth showed that in dry earth they died out, very rapidly at first and then more slowly, the progress again stopping short of sterilization. Temperature did not affect the results very seriously, but dampness was quite important. Finally, to test the effect of the purely physical purification effected by crystallization alone, we allowed ice to form freely on the surface of typhoid-infected water in a wine cask, and found that the ice contained only about 10 per cent. of the bacteria present in the water just below.

In summing up these results in a paper read before the American Academy of Arts and Sciences in December, 1899, our conclusions were given as follows: —

"The conditions which tend naturally to purify polluted waters are

well understood. Light, cold, and poor food supply are antiseptic agents of considerable power. . . . The main factor determining the reduction of germs in water is, however, the *time*,— the time during which these other forces are left to act. Epidemiology shows clearly that disease follows a direct, quick transfer of infectious material from patient to susceptible victim; and, if storage of water for some months could be insured, most sanitarians would consider that a sufficient purification.

"In ice we have this condition realized,— a forced storage of at least weeks and at best of many months. At the same time the other deleterious conditions are also heightened. The temperature is severe; and, while the ice remains upon the pond, the action of light must be intensified. It is no wonder, then, that our experiments show a reduction of over 99 per cent. in frozen typhoid bacilli; and we may be sure that in nature the destruction would exceed rather than fall short of such a limit.

"This reduction obtains in tubes which are frozen solid, where there is no chance for mechanical exclusion. In natural ice there is another purifying influence. Of the germs remaining in the water at the time of freezing, 90 per cent. are thrown out by the physical nature of that process. This reduction is separate from, and supplementary to, the antiseptic action of the cold. Therefore, when both factors work together, only one out of a thousand typhoid germs present in a polluted stream has a chance of surviving in the ice.

"Under natural conditions the pathogenic germs present in the most highly polluted stream are few in number. Of these few, one-tenth of one per cent. may be present in ice derived therefrom. These scattered individuals are weakened by their sojourn under unfavorable conditions, so that, as we have seen, they require nearly twice as long for their development as do the normal germs."

(We noticed in our experiments that the cultures made from the frozen water developed much more slowly in the artificial media than did those that were not so treated.)

"Evidently, those few and weakened germs cannot produce many cases of typhoid fever. . . .

"As long as absolute sterilization is not effected, there must always remain a certain element of doubt, as in the use of sand filters,

alluded to above, or in the practice of room disinfection after contagious diseases. The thickness of a layer of ice is often artificially increased by cutting holes in it and flooding that already formed with the water of the pond. In such a case the effects of crystallization are excluded, as in the laboratory tubes. Ice thus formed might be cut at once, and served within a week or two; and in such an exceptional case we cannot say that sufficient of the virus might not persist to excite the malady. Yet such an instance must be most exceptional; and the general result of human experience, the absence of epidemics of typhoid fever traced conclusively to ice, the fact that cities like New York, and Lowell and Lawrence in this State, use habitually the ice of polluted streams, and yet maintain low death-rates from typhoid fever, all tend to support the conclusion at which we have arrived,— that ice can very rarely be a vehicle of typhoid fever."

These conclusions, presented, as I have said, to the American Academy and in abstract at the first meeting of the Society of American Bacteriologists, Dec. 29, 1899, were, I think, received with some surprise, if not with some incredulity. In the following spring, however, Dr. W. H. Park read a paper before the Boston Society of Medical Science) *Journ. Bost. Soc. Med. Sci.* iv. 213), in which he noted the percentage reduction in samples of ice formed from water inoculated with twenty different cultures of typhoid bacilli. Nineteen cultures behaved as did those which Professor Sedgwick and I have used. One was more resistent, for the whole twenty cultures bringing the total average number surviving up to 7.5 per cent. after two weeks and .4 per cent. after three weeks. Dr. Park's results thus coincided in general with our own.

Dr. H. W. Hill, in a special report made to the Boston Board of Health only six weeks ago, after reviewing all the evidence, used the following telling illustration: "Beginning with a certain number of bacilli in the ice after three weeks, the percentage is the same as the percentage purification achieved in the city of Lawrence filter, and equivalent to the bacterial efficiency of 99.5 per cent. Hence water known to be infected with typhoid bacilli might, after standing three weeks from the date of freezing, be consumed with no more danger than that involved in drinking infected water after efficient filtration."

And now Mr. Clark, with his interesting and valuable experiments upon infected waters, sewage, etc., confirms our conclusion derived from experiments upon typhoid and B. coli.

It is undoubtedly true that typhoid fever may conceivably be carried by ice. If fæcal matter or sewage were frozen solidly into a mass of ice, say by flooding of the surface of ice already formed, the results of the various experiments would scarcely apply. Dr. Park showed that typhoid bacilli in fæces did not appear to be very greatly affected by cold, and our earth experiments led to the same conclusion. The great Plymouth epidemic caused by fæcal matter thrown out on the snow may come under this head. At the same time it appears to be a fact that ice formed under any ordinary conditions, even on waters so polluted as to be unfit for drinking, is likely to be so purified as not to be an important source of infection, though it is theoretically worthy of consideration.

PERCENTAGE REDUCTION OF TYPHOID BACILLI IN ICE.

Time frozen.	*Races* A.	B.	C.	D.
15 minutes	59.4	13.8		
30 "	63.7			
90 "	—	32.2		
2 hours	73.6			
3 "	—	41.4	99.5	74.8
6 "	83.3	—	—	97.0
12 "	—	38.6	—	84.4
15 "	—	—	89.0	
24 "	—	53.8	82.7	99.0
3 days	—	98.4	99.9	
7 "	—	93.3	99.5	
2 weeks	99.8	99.4	99.9	
4 "	99.8			
8 "	99.8			
12 "	99.8			

PERCENTAGE REDUCTION OF TYPHOID BACILLI IN WATER.

Temperature.	*Race D.* *Time.* 3 *hours.*	6 *hours.*	12 *hours.*	24 *hours.*
20°	70.8	72.6	85.7	88.4
10°	63.1	74.0	87.4	95.5

Dr. HILL.— Mr. Winslow has very gracefully quoted part of my report; but it is only fair to say that that report itself was based in part on his work and that of Dr. Park, Dr. Clark's work not having appeared at that time.

I should like to ask Mr. Clark in regard to a certain standard which has been prescribed by various cities, Cleveland, Ohio, among them, for the chemical analysis of ice. They prescribe in their regulations that ice shall not yield certain amounts of ammonia, chlorine, etc., under penalty of being excluded from the market. I have supplied Mr. Clark with the figures; and I should like to ask him to comment upon them as proper standards for boards of health to adopt, or as improper standards.

Mr. CLARK.— I think that it is probably more logical to adopt a standard of purity for ice than for waters; that is, that ice used or sold shall not contain over so much nitrogen or so many bacteria. It is more logical, I repeat, to adopt a standard of that sort for ice than for water, because you can certainly take even sewage and freeze it under such conditions that you will get a very fair quality of ice; while waters, of course, vary from natural conditions, geological, etc., in different parts of the country, and a standard for one part is not at all applicable to another part. Looking over this standard handed me by Dr. Hill that, I believe, is the standard of the boards of health of the cities that Dr. Hill has mentioned, I don't think that it is severe at all, because, as I have said, you certainly can take a pretty fair sample of sewage and freeze it, and still not have any more organic matter in the ice produced than is allowed by this standard. Of course, also, it is all right to say that the ice shall not contain any pathogenic organisms, nor more than 100 bacteria per cubic centimetre. I don't believe that good ice ever does contain more than 100 bacteria per cubic centimetre, and it certainly should not contain any pathogenic organisms.

The PRESIDENT.— Cannot you help us in the discussion, Dr. Chapin? You have had some Rhode Island experience in this matter.

Dr. CHAPIN, of Providence.—Mr. President, I certainly cannot add anything to what Mr. Clark has said, and Mr. Winslow, and Dr. Hill. They have the expert knowledge, and they have made the

experiments; and they know whereof they are talking. But I can say that I thank Mr. Clark and these other gentlemen that we can now drink all the ice water that we want to, and I hope those finicky people who feel obliged to cool their spring water in bottles set on the ice will now drink their ice water from the ice pitcher. While I feel duly grateful for these assurances of the wholesomeness of ice, yet I feel that that is only one of the minor points of value in Mr. Clark's paper. It is the character of the paper, and the investigation as a whole, of which I wish to speak. It is just exactly the kind of a paper that we would expect from Mr. Clark, and the kind of an investigation that we would expect to be undertaken by the Massachusetts State Board of Health. In our investigations of sanitary problems, I think in almost every case we should let the two sorts of investigation go hand in hand, what might be called the clinical studies and the laboratory studies; and that has been done in this problem. I feel that in the past, too often, our sanitary problems have been solved in somewhat this way: Some enthusiast, from a superficial investigation, or as a result of his own enthusiasm, has made certain dogmatic statements about the danger of certain things, such as typhoid in ice, or in oysters, or in celery, or dangers from sewer gas, or from something else; and he has published his statements perhaps in the medical journals. They have been read by health officers and by practising physicians, they have sunk deep into their hearts, they have talked about them, the public has read them, the reporters have added a touch or two, and, finally, we have got a great excitement about these questions. Then the city council or the board of health or the legislature are approached, perhaps, by interested parties; and we have elaborate laws upon the statute books forbidding the sale of certain kinds of ice, or of oysters grown in sewage, contaminated water, or of milk containing over a certain number of bacteria, or other regulations of that kind.

That is not the way to attack these problems. We should attack them in just exactly the way the Massachusetts State Board of Health attacks them. In investigating this ice question, they investigated first the clinical side of it; and they found, so far as they could learn,—and they have looked into the matter very carefully,—that disease has not been caused by the use of ice. Typhoid fever

epidemics have never been traced to ice. I would say that that is a point that I have had in mind in Providence for the last sixteen years. The kind of ice used by every typhoid case has been noted, and no outbreak of fever has ever been traced to ice. That is one side of the question. The evidence is here all on one side. There is no clinical evidence of danger in the use of ice as ordinarily put upon the market. But I do not believe that it is wise to trust to the clinical evidence alone, when we have laboratory methods of investigating the problem. These methods were employed by Mr. Clark, by Mr. Winslow, and by Dr. Hill; and they support the clinical evidence. They show very conclusively the reasons why there is no danger in drinking ice water, although the ice may be cut from rivers or ponds whose water would be somewhat dangerous to drink. The methods of investigation are the right methods; and they should be applied not only to this question, but to a dozen other questions, some of which I have named, and others which you will all think of. I hope that it will be the policy for this Association to apply such methods before they place themselves upon record as expressing their opinion upon any of these mooted points. [Applause.]

Dr. HILL.— It may interest the Association, possibly, to know in connection with what Dr. Chapin has been saying — although I don't know that he knows this particular fact — that interested parties have been making the statement of late that 29 per cent. of typhoid comes purely from natural ice. It is needless to say that the members of Boards of Health all over the country would welcome such a thing if it could be established as a fact, because the abolition of a natural ice supply then would do away with 29 per cent. of the typhoid. That statement is being made quite freely. I have heard that even from 40 to 60 per cent. of typhoid has been said to be due to natural ice. Of course, we can see exactly where such a statement stands in the face of what we have heard here.

Dr. FRENCH.— Mr. President, it occurred to me, while Dr. Chapin was thanking the Massachusetts Board of Health that he might be able to drink his ice water without any fear of typhoid; that we might be able to thank the gentleman that we could hereafter eat our Providence River oysters and lie down to pleasant dreams.

The PRESIDENT.—Mr. Underwood, hasn't this matter interested you?

Mr. UNDERWOOD.— Very much; but I don't think that I have anything to add to it, thank you.

The PRESIDENT.—The Association honored itself at its last meeting by electing to membership Professor Wesbrook of the University of Minnesota, and Professor Wesbrook sends the following note to the Secretary of the Association: —

Sir,— In acknowledging your letter of the 12th inst., I wish to express my appreciation of the honor the Massachusetts Association of Boards of Health has done me in electing me an honorary member.

I take great pleasure in accepting the membership tendered, and shall ask you to convey to the Association my thanks for the honor done me. I shall hope at some time in the future to have the privilege of attending some of your meetings.

Is there anything else to be said upon this subject of ice? If not, the Association is ready for any miscellaneous business that any member may care to bring before it.

Dr. HILL.—As the chairman of the Committee on Diphtheria is otherwise occupied for a moment, perhaps he will allow me to say unofficially that we have had returns from eight or ten places which promised to send us cultures on the subject of diphtheria bacilli in well persons. The total number of well persons examined to date, records of which have been sent us, is a little over four thousand, representing about eight thousand cultures; and we expect fully to get two thousand persons more, so that we will have finally six thousand persons, or twelve thousand cultures. The results have been tabulated partially, so far as they have been received; but it is an enormous piece of work to tabulate them, and I am afraid we shall not be able to report finally until the next meeting.

Mr. MARBLE.— Mr. President, I should like to inquire if any one present can give me any information as to the effectiveness of formaldehyde candles for fumigating purposes.

The PRESIDENT.— The Association has heard the question. Can you answer it, Mr. Clark? I am sorry to say that no member of the Association seems to have the necessary information.

Dr. HILL.— I might say that, although we have not personally experimented with them, we had occasion to look up what had been done in that line, and concluded that, if you used enough of the candles, you would get a disinfection from them just as well as from any

other form of formaldehyde. It is all a matter of getting enough gas into the room, and getting it in quickly; and you can get it from pastilles or from candles, and in many different methods, if you use enough of the reagent. Just how much to use is the great question. In Buffalo they made an investigation of the candles, the formaldehyde pulverized being mixed with paraffine; and they reported that they could disinfect in that way. They had to use more than the amount specified by the people who put it on the market, which is the usual experience with all disinfectants of this character. The Buffalo work is given in the December, 1900, monthly report of the Board of Health of Buffalo.

The PRESIDENT.— Dr. Davenport, have you had any experience in this matter?

Dr. B. F. DAVENPORT.— I have had no experience. I simply felt interested in the subject, and therefore consulted Dr. Durgin to learn if he knew anything about it. I thought, if they had any merit, he would be likely to know of it.

The PRESIDENT.— Dr. Tobey moves that we now adjourn.

Adjourned.

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